

Maastrichtian planktic foraminifera from northeastern Tunisia

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Maastrichtian planktic foraminifera from northeastern Tunisia

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Abstract A summary of nine articles on the Maastrichtian planktic foraminifera and biostratigraphy of the fossiliferous sedimentary beds at Kef en Nsoura, northeastern Tunisia, is presented. The papers describe and discuss the morphology, phylogeny and taxonomic position of the most important planktic foraminifera recorded in these beds. The identified species, three of which are new, belong to the families Globotruncanidae Brotzen, 1942, and Heterohelidae Cushman, 1927. Based on these species two parallel planktic foraminiferal zonations were distinguished in the Maastrichtian at Kef en Nsoura, one (complete) based on globotruncanid and a second (incomplete) based on heterohelid zone-markers. In addition to this summary a brief account of the general geology and Upper Cretaceous stratigraphy of the region in which the Maastrichtian beds at Kef en Nsoura are situated is given. The identification and position of the Campanian-Maastrichtian and Maastrichtian-Paleocene boundaries found in the sections studied are discussed and some taxonomic comments are presented.	
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Nikolaos Solakius

Date May 4, 1983

Maastrichtian planktic foraminifera from northeastern Tunisia

Nikolaos Solakius

Doctoral dissertation at the University of Lund, 1983, consisting of the following articles:

- (1) 1982: Description of a new species Globotruncana pseudoconica and remarks on its relation to Globotruncana conica White and Globotruncana falsostuarti Sigal. Geobios, no. 15, pt. 6, pp. 873-889. Lyon. (Offprint)
- (2) 1983a: Taxonomy of some Globotruncanidae and biozonation of the Late Maastrichtian of the El Haria Formation at Kef en Nsoura, Djebel Garci, Enfidaville region, eastern Tunisia. Notes du Service Géologique Tunisie, no. 46. Tunis. (37 pp., preprint. Subm. February, 1981.)
- (3) 1983b: A new planktic foraminiferal species from the Late Maastrichtian of Tunisia. N. Jb. Geol. Paläont. Mh., 1983 (2), pp. 113-118. Stuttgart. (Offprint)
- (4) 1983c: Morphological and phylogenetic studies of the species of the genus Abathomphalus Bolli, Loeblich & Tappan, 1957, (Globigerinacea, Foraminifera) from the Maastrichtian of Tunisia. Geobios, no. 16, pt. 2, pp. 139-159. Lyon. (Offprint)
- (5) (in press): Biozonation of the Maastrichtian of section II at Kef en Nsoura, Tunisia, and taxonomy of some Globotruncanidae. Revista Española de Micropaleontología. Madrid. (25 pp., preprint. Subm. February, 1982.)
- (6) (in press): Two parallel Maastrichtian biozonations of sections I and II at Kef en Nsoura, and taxonomy of some globotruncan-

nids. Notes du Service Geologique Tunisie. Tunis.
(23 pp., preprint. Subm. April, 1982.)

- (7) (in press): Heterohelcid zones and planktic foraminifera from the Maastrichtian of Kef en Nsoura, northeastern Tunisia. Notes du Service Geologique Tunisie. Tunis. (25 pp., preprint. Subm. December, 1982.)
- (8) (in press): Globotruncana falsocalcarata Kerdany & Abdelsalam, 1969, from the Upper Maastrichtian of Enfidaville, northeastern Tunisia. Geologica Carpathica. Bratislava. (11 pp., preprint. Subm. February, 1983.)
- (9) (in press): Use of the "petrol method" for extracting foraminifera from various types of sedimentary rocks. Proceedings of the Symposium on Laboratories/Methods. Special NPD Publication no. 2. Stavanger. (3 pp., preprint. Subm. January, 1982.)
- (10) 1983d: (Summary): Maastrichtian planktic foraminifera from northeastern Tunisia. Lund Publications in Geology, no. 2, pp. 1-22. Lund.

These articles are referred to in the following pages as papers 1 to 10.

Maastrichtian planktic foraminifera from northeastern Tunisia

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Solakius, N., 1983 05 04: Maastrichtian planktic foraminifera from northeastern Tunisia. Lund Publications in Geology, no. 2, pp. 1-22. Lund. ISSN 0281-1316.

A summary of nine articles on the Maastrichtian planktic foraminifera and biostratigraphy of the fossiliferous sedimentary beds at Kef en Nsoura, northeastern Tunisia, is presented. The papers describe and discuss the morphology, phylogeny and taxonomic position of the most important planktic foraminifera recorded in these beds. The identified species, three of which are new, belong to the families Globotruncanidae Brotzen, 1942, and Heterohelicidae Cushman, 1927. Based on these species two parallel planktic foraminiferal zonations were distinguished in the Maastrichtian at Kef en Nsoura, one (complete) based on globotruncanid and a second (incomplete) based on heterohelicid zone-markers. In addition to this summary a brief account of the general geology and Upper Cretaceous stratigraphy of the region in which the Maastrichtian beds at Kef en Nsoura are situated is given. The identification and position of the Campanian-Maastrichtian and Maastrichtian-Paleocene boundaries found in the sections studied are discussed and some taxonomic comments are presented.

Nikolaos Solakius, Avd. för Historisk geologi och paleontologi, Sölvégatan 13, S-223 62 Lund, Sweden. 25th April 1983.

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INTRODUCTION

The aim of this paper, which is the formal part of my doctoral dissertation, is to summarize the results of my previous studies on the Maastrichtian foraminifera and biostratigraphy of the fossiliferous sedimentary beds at Kef en Nsoura, northeastern Tunisia, presented in a series of papers. In this review the results are supplemented by remarks on the taxonomic position of some described species and by a discussion on: (1) the identification of and position of the Campanian-Maastrichtian boundary found in two new sections, section 4 at Kef en Nsoura and the section at Ain Mdeker, presented in this work for first time, and (2) the Maastrichtian-Paleocene boundary which is found in the previously sampled sections 1-3 at Kef en Nsoura as well as in the new section at Ain Mdeker. A short account of the geology and Upper Cretaceous stratigraphy of the eastern Tunisian platform where the sedimentary sequences are situated is also given.

The subject of my doctoral thesis was originally the Maastrichtian-Paleocene planktic foraminifera from the sections at Kef en Nsoura. However, since the Maastrichtian fauna presented an excellent opportunity for morphological and phylogenetic studies I have concentrated my investigations to the study of this fauna only. The work thus became a taxonomic and phylogenetic study of the most important Maastrichtian planktic foraminifera recorded in the sections, and a biostratigraphic study in which zonations have been distinguished in the Maastrichtian of the sections based on the identified foraminiferal species. Apart from the previously known planktic foraminiferal species three new species, Globotruncana pseudoconica Solakius, 1982, Globotruncanella kefennsoura Solakius, 1983, and Abathomphalus salajensis Solakius, 1983, were described. Phylogenies of selected species and genera have been presented.

In the study area, the planktic foraminifera show a high degree of species diversity and abundance which facilitates the correlation of the Maastrichtian zones in Kef en Nsoura with other Maastrichtian zones in other parts of the Tethyan bioprovince with satisfactory accuracy.

The section at Ain Mdeker was sampled for later use in my further studies on the Upper Cretaceous sedimentary rocks from the eastern Tunisian platform. However, when I studied the biostratigraphically important species Globotruncana falsocalcarata Kerdany & Abdelsalam, 1969, (paper 8), I also examined specimens of Globotruncana falsocalcarata from this section in which it occurs abundantly. As mentioned above, another reason that prompted me to present the section at Ain Mdeker in this study is that I have attempted to determine the position of the Campanian-Maastrichtian boundary by making an examination of this section and of section 4 at Kef en Nsoura.

GEOLOGICAL SETTING

The eastern Tunisian platform on which the study localities at Kef en Nsoura and Ain Mdeker are situated is the Tunisian part of the Pelagian block (Fig. 1). It represents one of the four major tectonic units of Tunisia as can be seen in a northwest-southeast transect of the country the other three being the Alpine zone, the Tunisian Atlas-intermediate chains and the Saharan platform.

As a part of the Pelagian block the eastern Tunisian platform, according to Burollet et al. (1978), formed "... a vast, stable platform which progressively but unevenly, subsided during the Mesozoic and Tertiary". In the west the platform is limited by a major lineament, a north-south axis, extending from Gabes to Tunis and bordering the Atlas Mountains of central Tunisia. Contrary to the eastern Tunisian platform the latter area was unstable and in the late Tertiary became folded as an intermediate peri-Alpine chain type (Burollet et al., 1978).

The north-south axis is a series of anticlines now overthrust by the Atlas in the area of Zaghouan. The axis constituted an important

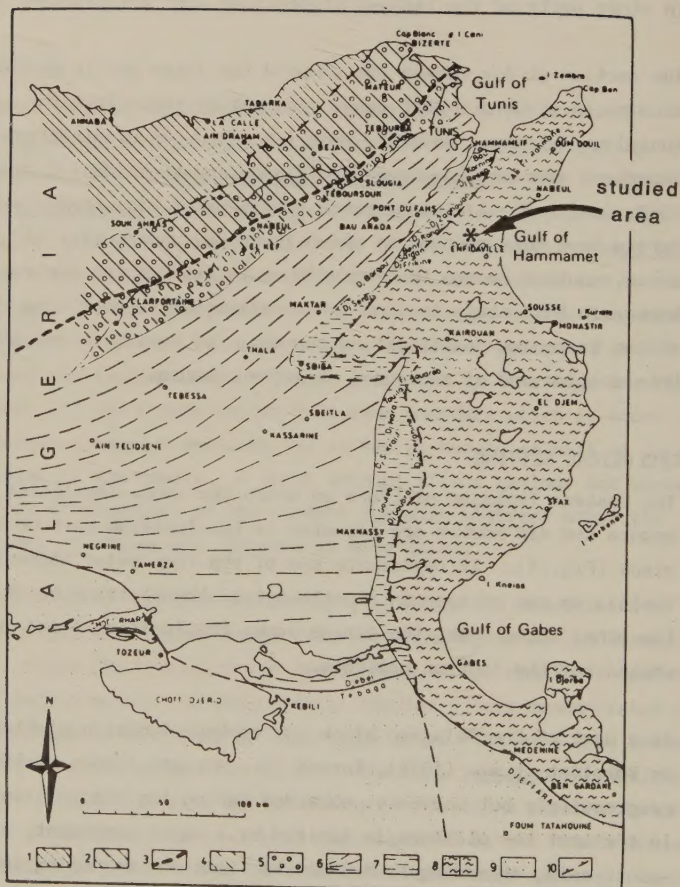


Fig.1. A tectonic sketch map of Tunisia. (I) Northern Tunisia—Alpine zone: (1) Numidian nappes, Tellian units, and para-autochthon of Hedil; (2) Medjerda para-autochthon and autochthon; (3) thrust zone of Teboursoou; (4) Miocene foredeep (also occurring in intermediate chains). (II) Tunisian Atlas—intermediate chains: (5) diapiric zone; (6) central and southern Atlas; (7) north-south axis. (III) Platforms: (8) eastern platform (western part of Pelagian block), structural depressions, and elevations of eastern platform; (9) Saharan platform; (10) thrusts. (from Salaj, 1978).

element in the geologic history of Tunisia in the late Mesozoic because it was a partition between two important tectonic units: the mobile zone in the west which now is occupied by the Tunisian Atlas and the more stable Tunisian platform.

The Upper Cretaceous sedimentary rocks are extensively exposed on the stable Tunisian platform as well as in southern, central and western Tunisia, as emphasized by Burollet (1956) and Salaj (1980). These rocks are subdivided into five lithostratigraphic units, originally distinguished by Burollet (1956) for the Upper Cretaceous rocks of central Tunisia and subsequently confirmed by Said (1978) and Salaj (1980) in the western and eastern parts of the country. The units are:

5. Abiod Formation, Campanian-Lower Maastrichtian
4. Aleg Formation s.s. Coniacian-basal Campanian
3. Binero Formation, Middle-Upper Turonian
2. Anaba Formation, Lower Turonian
1. Bahloul Formation, Upper Cenomanian-basal Turonian
- Fahdene Formation, Albian-Middle Cenomanian

The Abiod Formation passes upwards to the El Haria Formation which consists of Upper Maastrichtian and Paleocene sedimentary rocks. This formation was also established by Burollet (1956) in central Tunisia. Its extension to the eastern and western parts of the country has subsequently been confirmed by Salaj (1980).

The conditions under which the Upper Cretaceous sediments of the eastern Tunisian platform were deposited, differed from those for the Upper Cretaceous sedimentary rocks of the western, central or southern parts of the country. This was first observed by Pervinquière (1903) who distinguished three principal facies for the Senonian of Tunisia: the northern, central and southern facies.

Later Solignac (1927), discussing the facies of Pervinquière, stated that in addition to the central and southern facies two other facies occur (notone northern facies). These are the Tellian facies in the west near

the Algerian border, and the Tunisian facies in the eastern part of the country.

This division of the Senonian into distinct facies-types, which according to Solignac (1927) represent different "tectonic environments", is still valid and has recently been treated by Salaj (1978) who described them as follows:

- (1) The Tunisian facies includes the eastern part of the Tunisian Trough, north-central Tunisia, the northern part of the eastern Tunisian platform and the intervening part of the north-south axis. This facies is characterized by tectonic activity during this time interval, shallow-water sedimentation with breaks in the successions and condensed sequences. An important characteristic of the Tunisian facies is that in the Abiod Formation only one limestone horizon occurs.
- (2) North of the Tunisian Trough two Senonian facies can be recognized.
 - (2a) The Tellian facies, originally defined by Solignac (1927), is represented by a zone near the Algerian border (see Tellian units in Fig. 1). The sediments of this facies consist of hard blackish marls which are often brecciated. There are two limestone horizons in the Abiod Formation in this facies.
 - (2b) The northern facies of Pervinquière, which is represented in the Tunisian Trough and is linked with the autochthon of Medjerda and the region north of the central and southern Atlas (Fig. 1). As in (2a) there are two limestone horizons in the Abiod Formation.
- (3) The central and southern facies which were originally described by Pervinquière (1903) and according to Salaj (1978) are represented in "... the unstable zone of the southern part of the eastern platform south of a line from Sfax to Medenine and the intracratonic trough of the Chotts...". It also extends to the Saharan platform (Fig. 1). The sedimentary rocks of this facies consist of marls, sometimes gypsiferous, and organodentritical limestones with orbitoids. In the Abiod Formation only one limestone horizon occurs. The successions have breaks and in some places are transgressive.

As shown above, the Campanian-Maastrichtian sedimentary rocks of the eastern Tunisian platform belong to the Abiod and El Haria Formations and were deposited under a shallow-water conditions (Salaj, 1978). These beds are best represented in the vicinity of Enfidaville for instance the localities at Kef en Nsoura, Kef en Nehzal and Ain Mdeker. In these areas the Abiod Formation is composed of one limestone horizon as well as underlying and overlying condensed marl limestone alternations and thus differs from the Abiod Formation as described by Buroillet (1956) in central Tunisia (Salaj, 1980). The Abiod Formation passes upwards into the El Haria Formation the lowest layer of which comprises marls overlying the upper marl/limestone alternation of the Abiod Formation, followed by marl/limestone alternation which in their turn give way to beds of marl of Paleocene age.

LOCALITIES

The locality at Kef en Nsoura

This area is situated on the mountain Djebel Garci about 2 km from the village of Ain Garci and 12 km west of the town of Enfidaville (Fig. 2) and includes the locality from which the samples of sections 1-4 were collected. The area is disturbed by vertical and horizontal faulting.

Sections 1-3 at Kef en Nsoura were sampled from an area situated east of a north-south directed fault where the Maastrichtian-Paleocene beds occur. These beds dip 20° to the northeast and strike in a NW-SE direction.

West of the north-south fault is an outcrop here called section 4 at Kef en Nsoura consisting of limestone beds 188 m thick (Lazaar, 1971).

As mentioned in papers 2 and 5 sections 1 and 2 were sampled by Lazaar (1971) and Salaj (1969) respectively, and the material sent to me for investigation of the foraminiferal fauna. I sampled section 3 myself while Lazaar (1971) sampled section 4. His measurements have recently been confirmed by me.

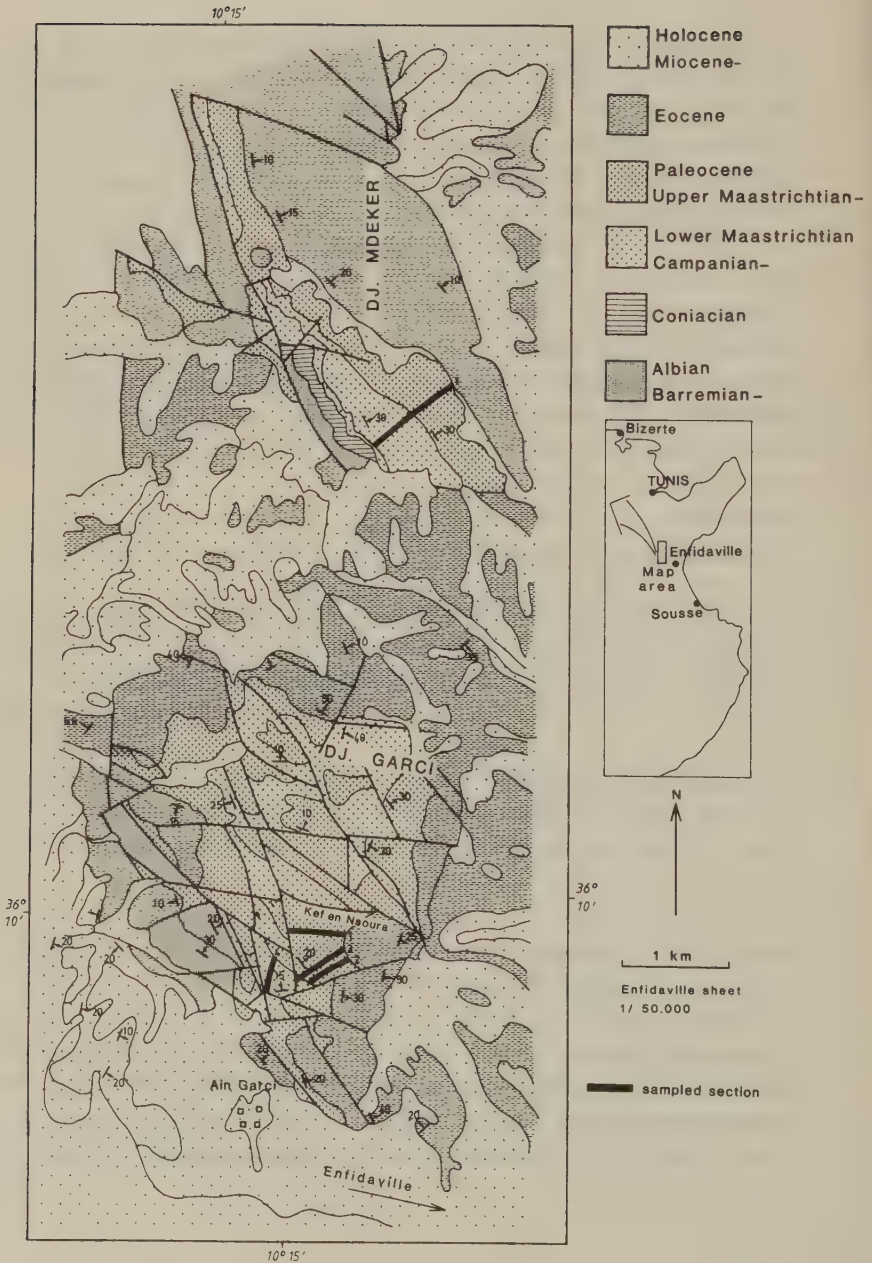


Fig. 2. Geological map of the areas of Kef en Nsoura and Ain Mdeker showing the location of the sections studied.

I have measured the Maastrichtian-Paleocene beds at Kef en Nsoura when I sampled section 3 and found the maximum thickness of these beds in that section to be 240 m (Fig. 3). I further found that the sequence begins with marls alternating with hard limestone beds 1-1.5 m thick. This part of the sequence (85 m) belongs to the Abiod Formation and represents the upper marl/limestone alternation of this formation. This alternation succeeded the Abiod Limestone of section 4 before the position of the limestone was changed by faulting. Above this Abiod upper marl/limestone alternation the sequence passes into the El Haria Formation, continuing with beds of marls 45 m thick which can be regarded as the Maastrichtian marls of this formation. These marls change upwards into beds of marls 95 m thick alternating with limestone beds 0.5-1 m thick. Within this marl/limestone alternation of the El Haria Formation the Maastrichtian-Paleocene boundary is found. The sequence continues upwards with marls 11.5 m thick which belong to the Paleocene and comprise the uppermost part of the El Haria Formation at Kef en Nsoura. The section is covered by Lower Eocene limestones which belong to the Met-laoui Formation (Burollet, 1956) (Fig. 3).

119 samples from the Maastrichtian of sections 1-3 and three samples from section 4 were investigated and the results are presented in this thesis (papers 1 to 10).

The locality at Ain Mdeker

The locality at Ain Mdeker is situated on the mountain Djebel Mdeker (Fig. 2), 2 km from the village of Ain Mdeker and about 15 km northwest of the town of Enfidaville.

One section at this locality was recently sampled by the author (Fig. 3). The beds have a thickness of about 194 m, dip to the northeast and strike in a NW-SW direction.

The sequence begins with marls alternating with limestone beds. This 6.5 m thick marl/limestone alternation belongs to the Abiod Formation and represents the lower marl/limestone alternation of this formation.

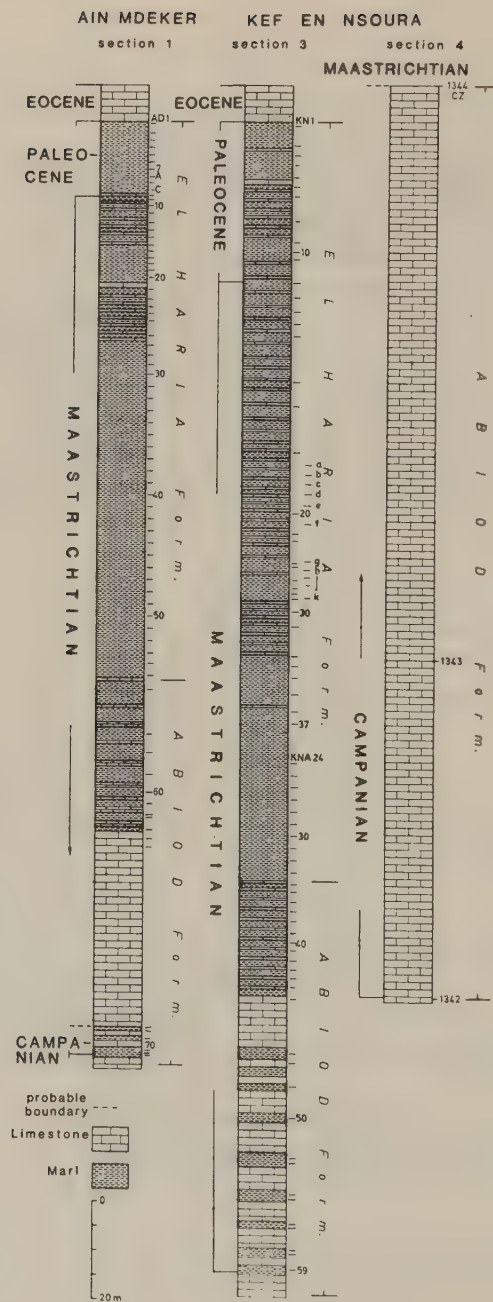


Fig. 3. Sections 3 and 4 at Kef en Nsoura and the section at Ain Mdeker showing the sampling, lithology and thickness of the sequences studied.

Above this alternation the Abiod Limestone, a 40 m thick limestone sequence, is situated. The lower part of the lower marl/limestone alternation belongs to the Upper Campanian while its upper part like the overlying Abiod Limestone is probably of Lower Maastrichtian age. The sequence continues upwards with a 32 m thick sequence of marls with alternating limestone beds 0.50-1 m thick. These beds are definitely of Lower Maastrichtian age and belong to the Abiod Formation. Above these beds the sequence passes into beds of marls 70 m thick belonging to the El Haria Formation. These marls are overlain by beds of marls alternating with limestone beds to a thickness of 30.5 m which pass upwards into beds of Paleocene marls 15 m thick. With these beds of marls the El Haria Formation ends at Ain Mdeker. The overlying El Haria Formation beds belong to the Lower Eocene limestone of the Metlaoui Formation (Fig. 3).

In this sequence as well the Maastrichtian-Paleocene boundary is found within the last marl/limestone alternation of the El Haria Formation. I examined 60 Upper Campanian and Maastrichtian samples in order to find the vertical distribution of the biostratigraphically important species Globotruncana falsocalcarata Kerdany & Abdelsalam, and to determine the position of the lower and upper boundaries of the Maastrichtian (Fig. 3).

LABORATORY METHODS

The collected samples were washed and dried according to standard micropaleontological methods. However, so that a successful extraction of foraminifera from hard and soft limestones could be effected such samples were first treated according to the "petrol method" to disintegrate the rock as described by the author in paper 9. This method was successful for extracting foraminifera from soft limestone though less so for hard limestone.

PLANKTIC FORAMINIFERA

Planktic foraminifera are considered the most suitable fossil group for

local, and especially for inter-regional and world-wide stratigraphic correlations. This is so because they have a wide geographical distribution, usually occur in great abundance and have a rapid rate of evolution.

Such correlations can only be successful when based on well-defined zones. The Maastrichtian planktic foraminifera studied in this investigation provided a sound basis for the recognition of zones in the sections at Kef en Nsoura that can be applied to inter-regional or world-wide correlation. This rich Maastrichtian fauna at the same time provided an excellent opportunity for carrying out a detailed study of the morphology and phylogeny of the species encountered, and also helped me to clear up the taxonomic confusion for some of the identified species.

The planktic foraminiferal species presented in the separate papers of this work belong to the families Globotruncanidae Brotzen, 1942, and Heterohelicidae Cushman, 1927. The heterohelicids exceed the globotruncanids and planomaliniids in numbers of species and specimens in section 1 (paper 2) as well as in the other sections.

The 24 globotruncanid species treated by the author in papers 2 and 5 are part of this fauna. The species are described and their phylogenies discussed in these papers. Most of the identified species are previously known and have been reported from various Maastrichtian sequences around the world. However, the taxonomic position and morphology of some of the species described were rather confused and in need of further discussion. One example is Globotruncana gagnebini Tiley, which by numerous authors is considered synonymous with Globotruncana aegyptiaca Nakkady. In paper 2 Globotruncana gagnebini is treated as a distinct Globotruncana species and not as synonymous with Globotruncana aegyptiaca. This is because the morphology of the two species differ. One difference is the size of the test of Globotruncana aegyptiaca which is larger than that of Globotruncana gagnebini. The last chamber of the last whorl of Globotruncana gagnebini, which

increases more rapidly in size in the direction of coiling than that in Globotruncana aegyptiaca and occupies 1/3 of the test, comprises another difference. There are also differences in the development of the keels. The double keel of Globotruncana gagnebini is sharply divergent on the face of the last chamber, while the keels of Globotruncana aegyptiaca vary in form and the amount of space between the two keels also varies. These differences in the morphology of the tests of the two species emphasize the fact that Globotruncana gagnebini is a distinct species and not a junior synonym of Globotruncana aegyptiaca as noted by other workers.

Rugotruncana gansseri (Bolli), Rugotruncana subcircumnodifer (Gandolfi) and Rugotruncana bahijae (El Naggar), all assigned by numerous authors to the genus Globotruncana in papers 2 and 5 are referred to the genus Rugotruncana Brönnimann & Brown, 1956. The reason for this is that these species exhibit mutual distinct morphological characteristics such as the discontinuous costellae or traces of costellae on the umbilical side of their tests, finely beaded keels and a Rugoglobigerina- or Archaeoglobigerina-like early stage of development of the test resembling that of the type species of the genus Rugotruncana.

Other species which were discussed extensively are Globotruncana conica White and the new species Globotruncana pseudoconica Solakius, 1982. In paper 1 I demonstrated that the strongly spiroconvex Globotruncana pseudoconica, which had earlier been assigned to populations of Globotruncana conica White, is a distinct Globotruncana species with a different phylogenetic history from that of Globotruncana conica White, and is for this reason described as a new species. The new species has evolved from Globotruncana falsostuarti Sigal, while Globotruncana conica is derived from Globotruncana stuarti (De Lapparent).

A rare but biostratigraphically very important species recorded in the samples from Kef en Nsoura and Ain Mdeker (papers 2 and 8) is Globotruncana falsocalcarata Kerdany & Abdelsalam. In paper 8 it is shown that the holotype of this species is a juvenile specimen while the paratype

is an adult. It is therefore suggested that the type representatives of Globotruncana falsocalcarata must be those which resemble the paratype. In this paper the probable function of the spines of this species is also discussed.

The representatives of the genus Abathomphalus Bolli, Loeblich & Tappan, 1957, constituted an evolutionary lineage which is derived from Globotruncanella havanensis (Voorwijk), 1937. In paper 4 it is shown that the two previously known Abathomphalus representatives evolved from a recently described member of the genus, Abathomphalus salajensis Solakius, 1983, which is the immediate descendant of Globotruncanella havanensis. The affinity of the Abathomphalus species and Globotruncanella havanensis has also been studied and demonstrated.

Another direct descendant of Globotruncanella havanensis is the recently described new species Globotruncanella kefennsoura Solakius, 1983, presented in paper 3. This species is a strongly spiroconvex Globotruncanella which together with Globotruncanella pyramidalis Longoria & Gamper constitute the only two strongly spiroconvex Globotruncanella species.

Globotruncanella pyramidalis is one of the eight species treated in paper 6. This species is the only one of the previously described species which is reported from Tunisia for the first time. In this paper the globotruncanid zones of the Maastrichtian is further discussed, and the globotruncanid index species as well as those which belong to the family Heterohelicidae and their presumed ancestors are illustrated. In this connection it must be stressed that the range of the genus Archaeoglobigerina Pessagno, is restricted to the lower part of the Upper Maastrichtian and does not extend to the top of the Maastrichtian (as was incorrectly stated in paper 6, Fig. 2).

The foraminiferal species discussed in paper 7 are members of the families Globotruncanidae and Heterohelicidae. The heterohelicids studied represent the index species of the incomplete heterohelical zonation presented for the sections. Their presumed ancestors are also described together with three important globotruncanid species.

TAXONOMIC COMMENTS

The classification of the planktic foraminifera used in the papers resembles that recommended in Treatise of Invertebrate Paleontology, Protista 2 (Loeblich & Tappan, 1964) except for a few modifications suggested by other authors. One modification is the recognition of Rugotruncana Brönnimann & Brown, 1956, which in the Treatise is given as a synonym of Globotruncana Cushman, 1927. Rugotruncana was originally described by Brönnimann & Brown (1956) as a genus resembling Globotruncana but differing in having the discontinuous costellae or traces of costellae. Pessagno (1967) subsequently stated that the species of this genus differ from Globotruncana species in that the costellae are always arranged meridionally, in showing angled or truncate peripheries and in possessing a Rugoglobigerina-like early stage.

All the above characters of Rugotruncana described by Brönnimann & Brown (1956) and by Pessagno (1967) are recognized by me on the specimens of Rugotruncana gansseri, Rugotruncana subcircumnodifer and Rugotruncana bahijae examined from Kef en Nsoura, and I regard them as diagnostic characters for the genus.

Another taxonomic modification is the recognition of Globotruncanella Reiss, 1957, which in the Treatise is treated as a synonym of Globotruncana. Globotruncanella was originally described by Reiss (1957) as a member of the subfamily Globotruncaninae Brotzen, 1942, with Globotruncana citae Bolli, 1951, as the type species. Reiss (1957) described this genus as closely related to Praeglobotruncana Bermudez, 1942, from which it probably evolved, but it differs from the latter in having a narrower but "undifferentiated" keel. Subsequently, Pessagno (1967) emended the diagnosis of this genus and further stated that the type species of Globotruncanella, Globotruncana citae Bolli, is synonymous with Globotruncana havanensis Voorwijk, 1937, a modification which has since been accepted by many authors including myself (see papers 2, 3 and 4). Pessagno has further placed this genus in the family Abathomphalidae Pessagno, 1967, where also placed Abathomphalus Bolli, Loeblich & Tappan.

In my studies on the members of Globotruncanella and Abathomphalus from Kef en Nsoura, I have treated these two genera as members of the family Globotruncanidae. This is because I believe that Globotruncanella and Abathomphalus are closely related, and both possess diagnostic features of Globotruncanidae, (as emphasized by Bolli (1957) for Abathomphalus and Reiss (1957) for Globotruncanella respectively). Thus they do not, in my opinion, diverge sufficiently from other members of Globotruncanidae to be placed in a separate family.

BIOSTRATIGRAPHY

As a result of the study of the planktic foraminifera species which were recorded from the sections and their stratigraphical range, parallel Maastrichtian zonations were distinguished in the sections at Kef en Nsoura; one complete zonation based on globotruncanid index species and a second incomplete zonation based on heterohelcid index species (papers 6 and 7).

The above zonations had earlier been presented by the author (papers 2 and 5) as a complete zonation consisting of two zones and three subzones based on globotruncanid and heterohelcid zone-markers. I have used this zonation as a base for the two parallel zonations presented, one zonation based on globotruncanids only and a second based on heterohelcids. The globotruncanid zones are of great significance for the correlation of the Maastrichtian in tropical and subtropical areas, while the heterohelcid zones are more useful in the temperate or boreal areas. A presentation of these zonations together with a description of the zones is given in papers 6 and 7. The zones are further compared with each other while the globotruncanid zonation was also correlated with the most important Maastrichtian zonations presented for Tunisia, and with Postuma's general zonation of the Maastrichtian (papers 6 and 7).

The zonations consist of the following zones:

Globotruncanid zonation

4	Zone of <u>Globotruncana falsocalcarata</u> Kerdany & Abdelsalam	Upper Maastrichtian
3	Zone of <u>Abathomphalus mayaroensis</u> (Bolli)	
2	Zone of <u>Rugotruncana gansseri</u> (Bolli)	
1	Zone of <u>Globotruncana falsostuarti</u> Sigal	Lower Maastrichtian

Heterohelcid zonation

3	Zone of <u>Racemiguembelina varians</u> (Rzehak)	Upper Maastrichtian
2	Zone of <u>Racemiguembelina fructicosa</u> (Egger)	uppermost
1	Zone of <u>Racemiguembelina textulariformis</u> (White)	Lower Maastrichtian

All the above zones represent parts of the Maastrichtian, the youngest time interval of the Cretaceous which is estimated to have a duration of 5 m. y. Its lower boundary, the Campanian-Maastrichtian boundary is dated to 70 m. y. and its upper boundary, the Maastrichtian-Paleocene boundary is estimated to 65 m. y.

THE BOUNDARIES OF THE MAASTRICHTIAN IN THE SECTIONS

In his work on the Globotruncana species in Tunisia Dalbiez (1955) has shown that the disappearance of the species Globotruncana calcarata Cushman marks the upper boundary of the Campanian. Salaj (1980) came to the same conclusion 25 years later, but added that the Campanian-Maastrichtian boundary in Tunisia is defined by the combined events of the disappearance of Globotruncana calcarata and the first appearance of Globotruncana falsostuarti Sigal. He further explained that the lower boundary of the Maastrichtian is recognized by the first appearance of the double-keeled form of Globotruncana falsostuarti Sigal.

However, the definition of the Campanian-Maastrichtian boundary in Tunisia was recently changed by Salaj & Maamouri (1982) when they noted that a new Upper Cretaceous time-interval, called Kefian, recorded by them in the sequence at El Kef, western Tunisia, can be recognized between

the Campanian and the Maastrichtian. According to these authors the disappearance of Globotruncana calcarata and the first appearance of Rugotruncana kefiana Salaj & Maamouri, 1982, mark the lower boundary of the Kefian, while its upper boundary is defined by the first appearance of Globotruncana falsostuarti Sigal. Within this interval Globotruncana calcarata globulosa Salaj & Maamouri, 1970, and Globotruncana stephensoni Pessagno, 1967, also appear.

It was not possible to confirm the presence of the Kefian in the areas investigated by me, because the sequences were condensed on the eastern Tunisian platform during the late part of the Upper Cretaceous. I have found instead, through an examination of the planktic foraminifera of section 4 at Kef en Nsoura (Abiod Limestone) in thin sections, that Globotruncana calcarata occurs in the lower part of the section but is lacking in the upper part, and the foraminifera of this part of the section seem to belong to the Maastrichtian.

In the sequence at Ain Mdeker, I found Globotruncana calcarata in the lower part of the marl/limestone alternation underlying the Abiod Limestone (40 m thick). The upper part of this alternation is probably of Maastrichtian age because Globotruncana calcarata is absent and other foraminifera, although very poorly preserved, seem to be of Maastrichtian age.

It can thus be concluded that the position of the Campanian-Maastrichtian boundary in the sequences at Kef en Nsoura occurs within the Abiod Limestone, while in the sequence at Ain Mdeker it is situated in the lower alternation of marls and limestones underlying the Abiod Limestone.

The Maastrichtian-Paleocene boundary on the other hand was easier to identify because it is situated within the upper marl/limestone alternation of the sequence at Kef en Nsoura (marl/limestone alternation in the El Haria Formation) as well as in the sequence at Ain Mdeker. It has been defined by the disappearance of the Maastrichtian planktic

foraminifera and the appearance of the small Danian globigerinids such as Globigerina taurica Morzova, Globoconusa daubjergensis (Brönnimann). The Danian deposits of the sequence will be investigated in greater detail during my future studies of the sedimentary rocks of the eastern Tunisian platform.

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